Mathematical Foundations for Machine Learning and Data Science (EE 212)

Credit Hours: 3

Instructor: Zubair Khalid

Schedule: Monday to Friday (10.15 AM – 12.15 PM)

Machine Learning and Data Science are being used these days in a variety of applications including, but not limited to, forecasting in economics and finance, predicting anomalies or signal analysis in engineering, identification of speaker in acoustics, detection of cosmic bubbles in astrophysics and diagnosis in medical imaging.

While machine learning and data science have enabled many success stories, and tools are readily available to analyse data or design machine learning systems, the strong mathematical foundations in these areas are of significant importance to understand, review, analyse and evaluate the technical details of the machine learning systems and data science algorithms that are usually abstracted away from the user. This course focuses on the mathematical foundations that are essential to build an intuitive understanding of the concepts related to Machine Learning and Data Science.

Topics covered are:

Linear Algebra: vectors and matrices, vector spaces, system of linear equations, eigen-value decomposition, singular value decomposition, regression, least-squares, regularization

Calculus: Multivariate calculus and differentials for optimization, gradient descent

Probability: probability axioms, Bayes rule, random variable, probability distributions

Statistics: descriptive stats, inferential stats, statistical tests

Introduction to Neural Networks: single and multi-layer perceptron(s), feedforward and feedback networks

Application to machine learning and data science: principal component analysis (PCA), time series forecasting, clustering etc

Hands-on exercises: Implementation of the exercises will be carried out in MATLAB or Python

There are no prerequisites as I will be focusing on fundamental concepts in EE212 (sophomore-level course). We only assume that you got a chance to study some of these concepts in high school or college. We will try to build geometrical sense or intuitive of the advanced concepts. For example, what is the interpretation of the eigenvalues and eigenvectors of the matrix; the least-square solution is also a least-norm solution, how; what is the trade-off between variance and bias, etc?

Preliminary information and the draft course outline (including lecture plan) is available on the course page: https://www.zubairkhalid.org/ee212_2020.html